Color Transfer Between Images In Correlated Color Space

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Based on the work of : **Xuezhong Xiao And Lizhuang Sio-Hoi , Ieng Marcel Valentin**

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(a) Target (b) Source (c) Result

Figure 1: Color Transfer in Correlated Color Space

Abstract

Color transfer between images is the process of altering the color of a target image based on a source image. The goal is to transfer the look and the feel of this last (i.e : *color characteristics*) to the target image in order to increase its visual appeal and improve its appearance (ex: converting a daylight image into a night scene, a cold color image into a warm one).

In fact,we must distinguish between : *color transfer* applied between two color target and source images (this article is dealing with this approach) and *colorization* that consists of colorizing a grayscale image that remains challenging due to its wide application(Cinema , educational art and for artistic purpose as well).

The use of the different statistical informations of the image (Mean, Standard deviation and Covariance) are the essence to apply the different *statistics-based* methods of transferring the colors in Correlated(XIAO; MA, 2006) , Decorrelated color space(REINHARD *et al.*, 2001).
In this Article, we are going to implement the Color transfer in *Correlated Color Space* specifically in *RGB* color space ,the output of this article are based on the work of Xuezhong Xiao And Lizhuang.

– **Keywords** : Colorization, Color Transfer, Image Processing.

1 Introduction

One of the most common tasks in image processing is to alter an image's color.This article describes a method for a more general form of color correction that borrows one image's color characteristics from another. $Figure 1$ shows an example of this process, where we applied the colors of a purple rose photograph to a red flower. We can imagine many methods for applying the colors of one image to another. Our goal is to do so with a simple algorithm, and our core strategy is to choose a suitable color space and then to apply simple operations there(WU *et al.*, 2013).in our case , we choose the RGB color space for our application.(XIAO; MA, 2006) Demonstrates that we can apply this method on any color space but we did not treat all the cases.

2 Previous Work

Since Color alteration is an active research area in the communities of image processing and computer graphics. The researches much related with our work in the area of color alteration include $color\ transfer$,$colorcorrection$, $colorization$ of grayscale images and its reverse processing(REINHARD *et al.*, 2001).all over the years there a huge development of the color transfer algorithms:

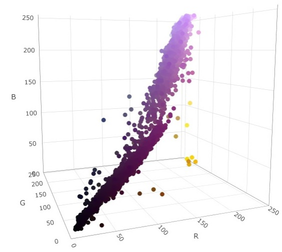
- ($Reinhard$ and his colleagues 2001) introduced a solid method for color transfer between images by working in $L^*\alpha^*\beta$ .they convert pixel values in $Ruderman$ et al perception-based color space .their statistics-based method computes the mean and standard deviations along each of the three axes, and then scale and shift each pixel in the input image.
- ($Gasparini$ and $Schettini$ 2003) introduce a reliable and rapid method of color correction for digital photographs on the $CIELab$ color space. Their algorithm can detect and remove a color cast in a digital image without any a priori knowledge of its semantic content. Several methods of colorization were proposed :
  - (greyscale image $Welsh$ et al 2002) Their method transfers the entire color mood of the source to the target image by matching $luminance$ and $texture$ information between the images and allows user interaction(WELSH *et al.*,).
  - ($Levin$ et al. 2004) presents a simple colorization method that requires neither precise image segmentation, nor accurate region tracking.

After studying some of the methods mentioned above.we decided to implement the Color transfer in a Correlated color space method.(XIAO; MA, 2006)

3 Color Transfer Algorithm

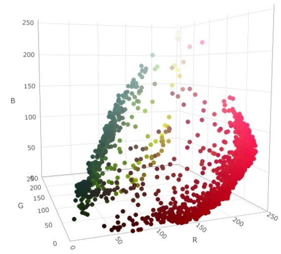
– From the view of statistics, we consider pixel's value as a three dimension $stochastic$ variable and an image as a set of samples, so the correlations between three components can be measured by $covariance$(can be deemed to the extension of standard deviation in correlated space). Our work will discuss the statistics-based method that imports $covariance$ between three components of pixel values while calculate the $mean$ along each of the three axes. Then we decompose the $covariance$ matrix using SVD algorithm and get a rotation,Translation matrix.
The essence of our method is moving data points of source image by **scaling**,**rotation** and **translating** to fit data points' cluster of target image in RGB color space (ie : match the three-dimensional distribution of color values between the two images source image's look and feels).

(a) Source

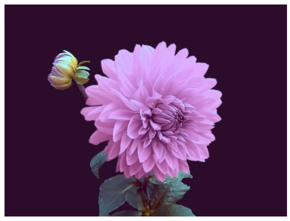


(b) Source cluster

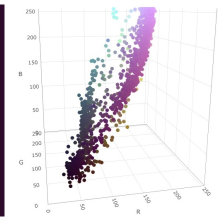
(a) Target



(b) Target cluster



(a) Result image



(b) result cluster

Figure 4: Scatter plots made in RGB for the Source,Target and result images

We used this tool to generate the 3D RGB cluster for the images.
figure 4 illustrates how a scatter plots of data points in RGB for the result image seems to fit data points' cluster of target image (**the three dimensional distribution are quite identical**). Now, we introduce how to do color transfer using the two statistics information(WELSH *et al.*,).First, we compute the $mean$ of pixel data along the three axes and the $covariance$ matrix between the three components in color space for both the source and target images. All of the statistics are denoted by : $(\bar{R}_{src};\bar{G}_{src};\bar{B}_{src})$, $(\bar{R}_{trg};\bar{G}_{trg};\bar{B}_{trg})$, Cov_{src} and Cov_{tgt} , respectively. Then, we decompose the covariance matrices using SVD algorithm ,the result we obtain is :

$$Cov = U * A * V^T \tag{1}$$

Where U and V are orthogonal matrices and are composed of the eigenvectors of Cov :

$$A = diag(\lambda^r; \lambda^g; \lambda^b) \quad (2)$$

Where : [$\lambda^r; \lambda^g; \lambda^b$are the eigenvalues of Cov. We employ U as a rotation matrix to manipulate pixels of the source image in the next step.(XIAO; MA, 2006)

Then, we do a transformation as below:

$$I = T_{src} R_{src} S_{src} S_{trg} R_{trg} T_{trg} I_{trg} \quad (3)$$

Where:

$$I = (R, G, B, 1)^T$$

and $I_{trg} = (R_{trg}, G_{trg}, B_{trg}, 1)^T$denote the homogeneous coordinates of pixel points in RGB space for the result and target images respectively;

$$T_{src}, T_{tgt}, R_{src}, R_{tgt}, S_{src} and S_{tgt}$$

denote the matrices of translation, rotation and scaling derived from the source and target images.

Notation : The subscripts of *src* and *tgt* represent for source image and target image, respectively

- Translation Matrix

$$T_{trg} = \begin{pmatrix} 1 & 0 & 0 & t^r_{trg} \\ 0 & 1 & 0 & t^g_{trg} \\ 0 & 0 & 1 & t^b_{trg} \\ 0 & 0 & 0 & 1 \end{pmatrix}, \; T_{src} = \begin{pmatrix} 1 & 0 & 0 & t^r_{src} \\ 0 & 1 & 0 & t^g_{src} \\ 0 & 0 & 1 & t^b_{src} \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

- Scaling Matrix :

$$S_{trg} = \begin{pmatrix} s^r_{trg} & 0 & 0 & 0 \\ 0 & s^r_{trg} & 0 & 0 \\ 0 & 0 & s^r_{trg} & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}, \; S_{src} \begin{pmatrix} s^r_{src} & 0 & 0 & 0 \\ 0 & s^r_{src} & 0 & 0 \\ 0 & 0 & s^r_{src} & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$$

- Rotation Matrix :

$$R_{src} = U_{src} \qquad R_{trg} = U_{trg^{-1}}$$

Where :
$t^r_{trg} = -\bar{R}_{trg}$, $t^g_{trg} = -\bar{G}_{trg}$, $t^b_{trg} = -\bar{B}_{trg}$ and $t^r_{src} = \bar{R}_{src}$, $t^g_{src} = \bar{G}_{src}$, $t^b_{src} = \bar{B}_{src}$.

$s^r_{trg} = \frac{1}{\lambda^R_{trg}}$, $s^g_{trg} = \frac{1}{\lambda^G_t rg}$, $s^b_{trg} = \frac{1}{\lambda^B_{trg}}$ and $s^r_{src} = \lambda^R_{src}$, $s^g_{src} = \lambda^G_{src}$, $s^b_{src} = \lambda^B_{src}$.

The statistics-based color transfer method can naturally extend to any 3D color space through replacing R, G and B with three components in another color space.

4 Results and Performances

The results obtained with this transformation are represented below.The next Figures show the effectiveness of the statistics-based method.we can obviously see the effect of the color transfer between the two images.despite the fact that this algorithm gives some great results but still not working on others examples (see figure 14)

Figure 5: Target

Figure 6: Source

Figure 7: Result

The result image feel is changed in a good way, we could see the details of the color obtained after transfer(Walls in blue , sky color changed ...).
Another example of the application :

Figure 8: Target

Figure 9: Source

Figure 10: Result

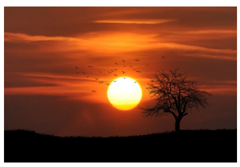
The algorithm has successfully transfer the purple look to the target image, we can notice that bright regions(sky color) and dark regions(tree) didn't change at all.

Figure 11: Target

Figure 12: Source

Figure 13: Result

(a) Target



(b) Source

(c) Result

Figure 14: A bad color Transfer example

In some cases, such as figure 11, the global transfer may fail because of the dissimilarity in composition between the source and target images.

5 Conclusion

In this work, we discuss a color transfer method that can borrow one image's color characteristics from another in RGB three dimension color space directly. Imposing mean and covariance onto the data points is a very simple operation, which produces believable output images given suitable input images. This method efficiency depends also on the similarities between the chosen images.(Bad Test in figure 14)

6 Acknowledgment

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